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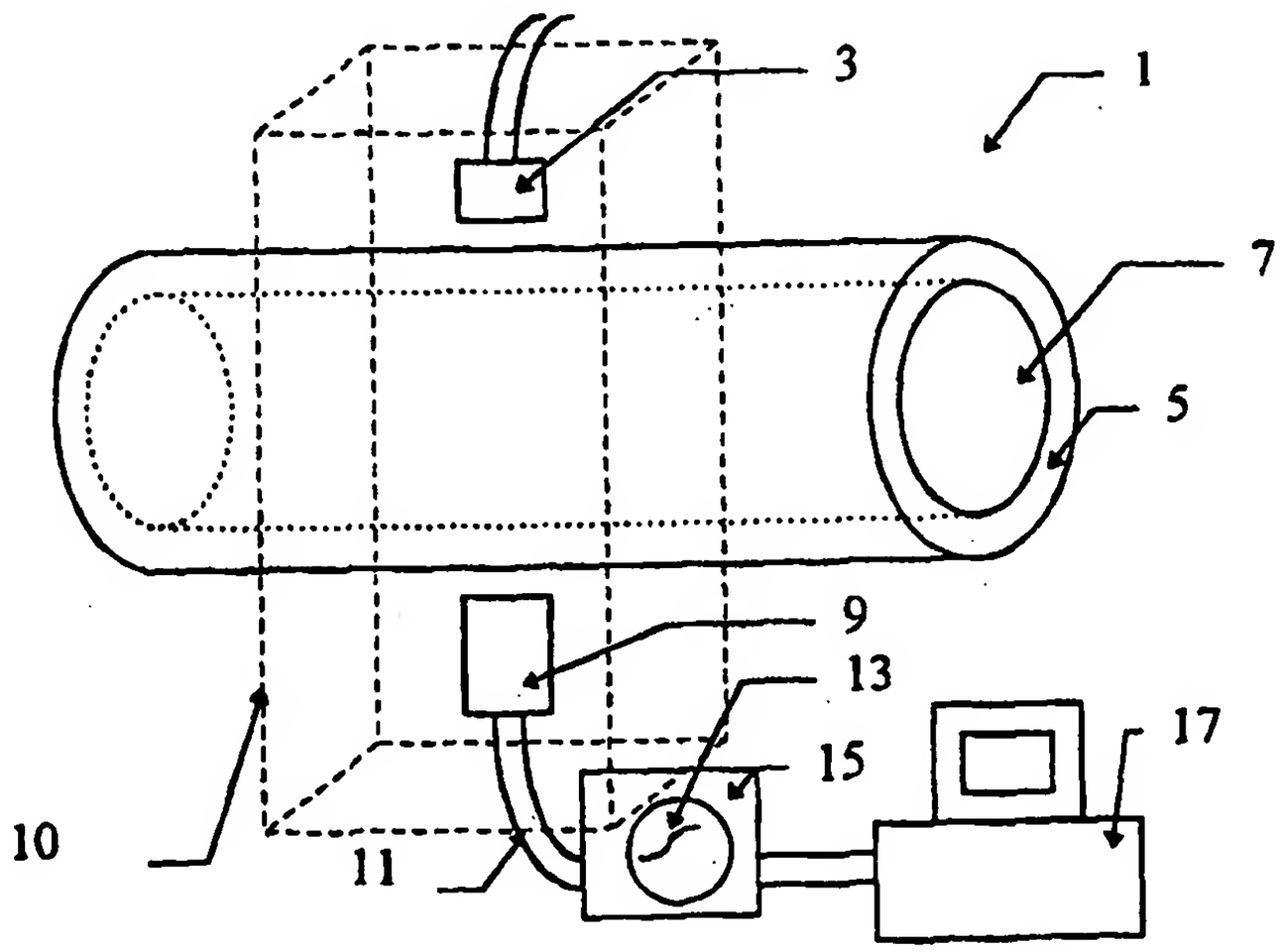
(54) Title: FLUID SENSING DEVICE AND METHOD FOR USE IN PARTICULAR IN MILKING MACHINES

(57) Abstract

The present invention relates to a device (1) for sensing the composition of a fluid (7). The device (1) comprises a container (5) for the fluid (7) and a light source (3) and light detecting means (9) positioned on opposite sides of the container (5). The amount of light detected by the light detecting means (3) is dependent on the composition of the fluid (7).



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FLUID SENSING DEVICE AND METHOD FOR USE IN PARTICULAR IN MILKING MACHINES

The present invention relates to a fluid sensing device and method for use in particular in milking machines of the type mentioned in the preamble of claims 1 and 9.

In milking machines it is necessary to regularly clean the pipe system leading from the milked animals udder to the milk storage container. This is done by flushing the system with cleaning fluids and it is important to be able to distinguish between water, milk, milk diluted with water, cleaning fluid, air, etc. in the hoses or pipes so that milk is not inadvertently sent to a container intended for waste products and so that waste products, cleaning fluid or contaminated milk are not sent to containers intended for pure milk. It is often also important to detect when a teat or udder has finished supplying milk to prevent excessively prolonged stimulation of the empty teat or udder.

Patent document US-A 4 756 274 describes an end of milking detector for use in a pipe in which a horizontally directed infra-red light source sends a beam of infra-red light to a detector on the opposite side of the pipe. If the fluid in the pipe reaches or passes above the level of the infra-red light source the beam is prevented from reaching the detector and it is assumed that the pipe is full of milk. This device can only determine that there is an absence or presence of milk (or other light blocking substance) above the level of the detector in a pipe. It cannot accurately measure how full the pipe is and it cannot measure the composition of the substance blocking the light beam.

Patent document US-A 5 116 119 describes a device for measuring liquid flow. This device has one or more channels through which the fluid flows and each channel contains a pair of sensors. Each sensor comprises an emitter of electromagnetic radiation and a receiver positioned on the side of the channel opposite the emitter.

The attenuation of the radiation received by the receiver is used as a measure of the momentary volume of the fluid flowing through the channel. This device is unsuitable for detecting the presence and flow of clear fluids.

The device and method of the present invention have the object of solving the problems of the prior art.

The object is achieved according to the present invention by means of a device and a method having the features mentioned in the characterising parts of the independent claims. Further developments and improvements of the present invention are mentioned in the dependent claims.

The invention will be described more closely with the help of examples of embodiments and the appended figures in which:

Figure 1 is a schematic perspective lateral view, partly in section, of one embodiment of a sensing device according to the invention;

Figure 2 shows a graph displaying the output against time of the sensing device of figure 1;

Figure 3 shows a schematic side view of an embodiment of a sensing device in accordance with the invention in a supply line.

The sensing device 1 shown in Figure 1 comprises a light source 3, such as a visible light emitting diode, on one side of a transparent container 5, such as a transparent glass or plastic pipe having a circular cross-section, holding the fluid 7 being examined and a light detecting means 9 e.g. a light sensitive resistor or a photo diode, mounted on the opposite side of the container, which is sensitive to the light emitted by the light source and which generates an output signal 11, e.g. a voltage, proportional to the light it receives. Light detecting means 9 is preferably directly

opposite light source 3. Preferably light detecting means 9 and light source 3 are arranged with one vertically above the other so that even small quantities of fluid in the container 5 interrupt the path of the light between the detecting means 9 and light source 3 and can be detected. In the example shown in figure 1 the pipe 5 is intended to be part of a milking device and the fluid 7 could be air, water, cleaning fluid, milk or the like which is flowing through the pipe 5. The output signal 11 is represented here symbolically by a trace 13 on an oscilloscope screen 15 but in the preferred embodiment the output signal 11 is processed by calculating means such as a computer 17. The trace 13 varies as the composition of the fluid between the light emitting source 3 and the light detecting means 9 varies. While for the sake of simplicity the light source 3 and detecting means 9 have been shown spaced a distance from the pipe 5 in practice the best results can be achieved by having them in contact with the pipe 5 and, possibly, mounted in blind recesses formed in the wall of the pipe 5. In the latter case the base of the recesses prevent the fluid in the pipe 5 from coming into contact with these components. In order to prevent ambient light affecting the light detecting means the device in accordance with the present invention is preferably surrounded by a light-tight casing or cover 10.

The amount of light received by light detecting means 9 is dependent on a number of variables, such as, for example, the strength of the light source 3 and the distance between the light source 3 and light detecting means 9, the opacity of the fluid 7 in the container 5 etc. If all the other variables are kept constant then any variation in the amount of light detected by light detecting means 9 is dependent on the composition of fluid 7. The output signal or voltage 11 generated by this light can be analysed, for example by comparison to the signals received from calibration mixtures of known composition, in order to determine the composition of the fluid in the pipe. This comparison can be performed manually by an operator, for example by comparing an output signal against calibration charts showing output signals obtained for different fluids of known composition. Alternatively one or more threshold levels can be set which corresponds to one or more desired opacities of the fluid being tested. Then when the detected light passes a certain threshold a a

visual signal such as a lamp or strobe light and/or an audible signal such as a bell or buzzer can be activated. This embodiment has the advantage that it is easy to implement without requiring the use of a computer. However in the preferred embodiment of the invention the comparison is performed by automated means such as computer 17. Once the composition of the fluid in the pipe 5 has been determined it is possible to use this information to control valves (not shown) so that the fluid 7 is guided to the correct destination. It is also possible to control valves to change the composition of the fluid e.g. by opening or shutting a cleaning fluid supply valve or a milk supply valve.

Calibration of the device can be performed by passing calibration fluids of known composition through the device and comparing the output signal against the expected output signal.

Figure 2 shows a graph of how an output voltage signal for a sensing device according to the invention could vary as different fluids pass through the pipe 5. When the pipe 5 contains only air (as shown in the section of the graph marked "air") a certain voltage Vair will be generated and when the pipe 5 is completely filled with a clear fluid such as water which has a refractive index which is different to the refractive index of air the pipe 5 will act as a magnifying lens to concentrate the light onto the detector and a higher voltage Vwater will be generated (as shown in the section of the graph marked "water"). When the pipe 5 is completely filled by an opaque fluid such as milk (as shown in the section of the graph marked "milk") then a lower voltage Vmilk will be generated and this voltage will rise towards Vwater if the milk is diluted with water and vice versa. Thus the voltage generated can be used to determine what percentage of milk and water is in the pipe. By using a sufficiently sensitive light detecting means 9 the sensing device can be made to detect extremely small instantaneous variations (such as "var" as shown in the enlarged part of fig. 2) in the opacity of the fluid 7 and, since milk or milk and water always has some tiny variations in opacity, it can also detect if the fluid is moving. In the region of the graph between Vair and V water each generated voltage could

correspond to a mixture of air and water or a mixture water and milk. It is possible to determine which type of mixture is present by checking which valves are open or by studying the variation "var" in the signal which has different characteristics depending on whether a clear mixture of air and water is present or an opaque mixture of milk and water.

Figure 3 shows an embodiment of a device in accordance with the present invention for use in a system which is subject to large variations in flow rate and composition of the fluid passing through it. Such large variations are common in milking systems in which slugs of milk are followed by bursts of air and in which the milk flow rate can varies from zero up to several litres per minute. The device shown generally by 31 is fitted across a comparatively narrow bypass-tube 33 which is below a larger diameter supply tube. As the bypass-tube 33 is below the supply tube 35 then liquids in the supply tube will tend to fill up the bypass tube before they start flowing through the supply tube. Preferably the sensing device 31 is positioned at the lowest point of bypass-tube 33 so that only a small volume of fluid is required to fill the cross-section of the bypass-tube 33 by the sensing device 31.Therefore even with small flow rates it is possible to accurately sample the fluid as long as the volume of fluid which collects in the bypass-tube 33 is sufficient to fill the cross-section by the sensing device 31. When the flow of fluid in the supply tube 35 then most of the fluid will pass through the bypass-tube 3. As the fluid flow increases more and more of the fluid will flow through the supply tube 35. It is useful to have a large diameter supply tube 35 as this reduces the pressure losses in the system while the use of a narrow diameter bypass-tube 33 allows accurate sampling of small quantities of fluid.

The presence of blood or other coloured contamination can be detected by using a suitable, preferably removable, colour filter or a providing more sensing devices according to the invention, each having a filter or light source adapted to enable the detection of different contaminants.

Clotting of milk can be detected by analysis of the signal as the passage of clumps of clotted milk will cause easily detected dips in the signal.

Accurate measurement of the velocity of the fluid can be obtained by using two or more sets of light sources and detector spaced a known distance apart in the direction of flow of the fluid being examined. By comparing the signals generated by the spaced apart detectors in order to identify similar irregularities in the signals the speed of the flow can be calculated from the time it takes for irregularities in the waveform of the first generated signal to appear in the second generated signal.

As the light source and sensing means are on the outside of the pipe there are no problems in keeping them clean and no special sealing arrangements are required.

The lens effect of the circular cross-section makes it possible to determine if the pipe contains air or water. This is because a water-filled pipe 5 acts as a converging lens and more of the light emitted by the light source 3 is focused onto the detecting means 9 than is the case with an air-filled pipe 5. While the invention has been illustrated with an example of a pipe with a circular cross-section, a magnifying effect can also be achieved by using a pipe with another suitable cross-section e.g. oval, semi-circular, convex, bi-convex etc. Alternatively if a triangular (or other multi-sided) cross-section pipe with straight sides is used then the pipe will act as a prism and will refract the incident light through an angle which depending on how full of fluid it is. By providing a continuous line of spaced-apart light sensing means in a line corresponding to the possible paths that the refracted light can take it is possible to measure the degree of fullness of the pipe as well as the composition of the fluid in it.

The invention has been illustrated by an example of an embodiment in which the container is made of a transparent material. It is also conceivable to make the container material from a translucent material. It is furthermore conceivable to use an electromagnetic radiation source which does not produce visible light e.g. a

source of infra-red radiation or ultra-violet radiation instead of, or in combination with, the visible light source mentioned above. In order to reduce the effects of the material acting as a light guide it is conceivable that it can be necessary to surround the detector with a light-proof shield or use some other shielding means to ensure that only light which passes through the fluid in the container is received by the detector.

In another embodiment of the invention (not shown) a single sensor according to the invention can be used to measure the flow in a pipe. This can be achieved by providing a pipe with such a large cross-sectional area that it never becomes completely filled by fluid during normal use. It is therefore possible to measure the depth of fluid as it passes between the source and detecting means. This depth can be used to calculate the flow rate if the size of the pipe and the force causing the flow, e.g. a head of pressure or a suction, are known.

While the invention has been illustrated as detecting the composition of moving fluids it is also suitable for modification to analyse static fluids. In other words a device in accordance with the present invention could be constructed in a container which can be filled with a sample of the fluid of interest which can then be analysed. The device could be used to sense the mixing of an opaque fluid or powder in a clear liquid, wherein the transparency of the liquid decreases as the opaque fluid or powder is mixed in. The output signal will therefore diminish in strength as the mixing takes place and complete mixing is indicated by the output signal reaching a steady-state.

Claims

1. Device for use in milking machines for determining the composition of a fluid in a container (5) wherein said container (5) is in the path of a beam of electro-magnetic radiation emitted by a source (3) and detected by a detecting means (9), characterised in that said container (5) has a cross-section in the path of said beam which is arranged, when liquid-filled, to concentrate said beam onto said detecting means (9).

2. Device according to claim 1 characterised in that said container (5) is transparent to visible or infra-red light or translucent in said path of a beam.

3. Device according to any of the previous claims characterised in that said container (5) has a circular, convex, semi-circular or oval cross-section.

4. Device according to any of the previous claims characterised in that said source (3) and said detecting means (9) are vertically spaced apart on opposite sides of said container (5)

5. Device according to any of the previous claims characterised in that said container is a pipe (5).

6. Device according to any of the previous claims characterised in that there is a filter in said path of the beam.

7. Device according to any of the previous claims characterised in that said beam is a beam of visible light or infra-red radiation.

8. Device according to any of claims 1-7 characterised in that it comprises a plurality of sources (3) and detecting means (9).

9. Method for use in milking machines for determining the composition of a fluid in a container (5) characterised by the steps of:

positioning said container (5) with a cross-section in the path of a beam emitted by a source (3), which cross-section is arranged, when the container is liquid-filled, to concentrate said beam onto said detecting means (9);

detecting by means of a detecting means (9) the amount of the beam passing through said fluid;

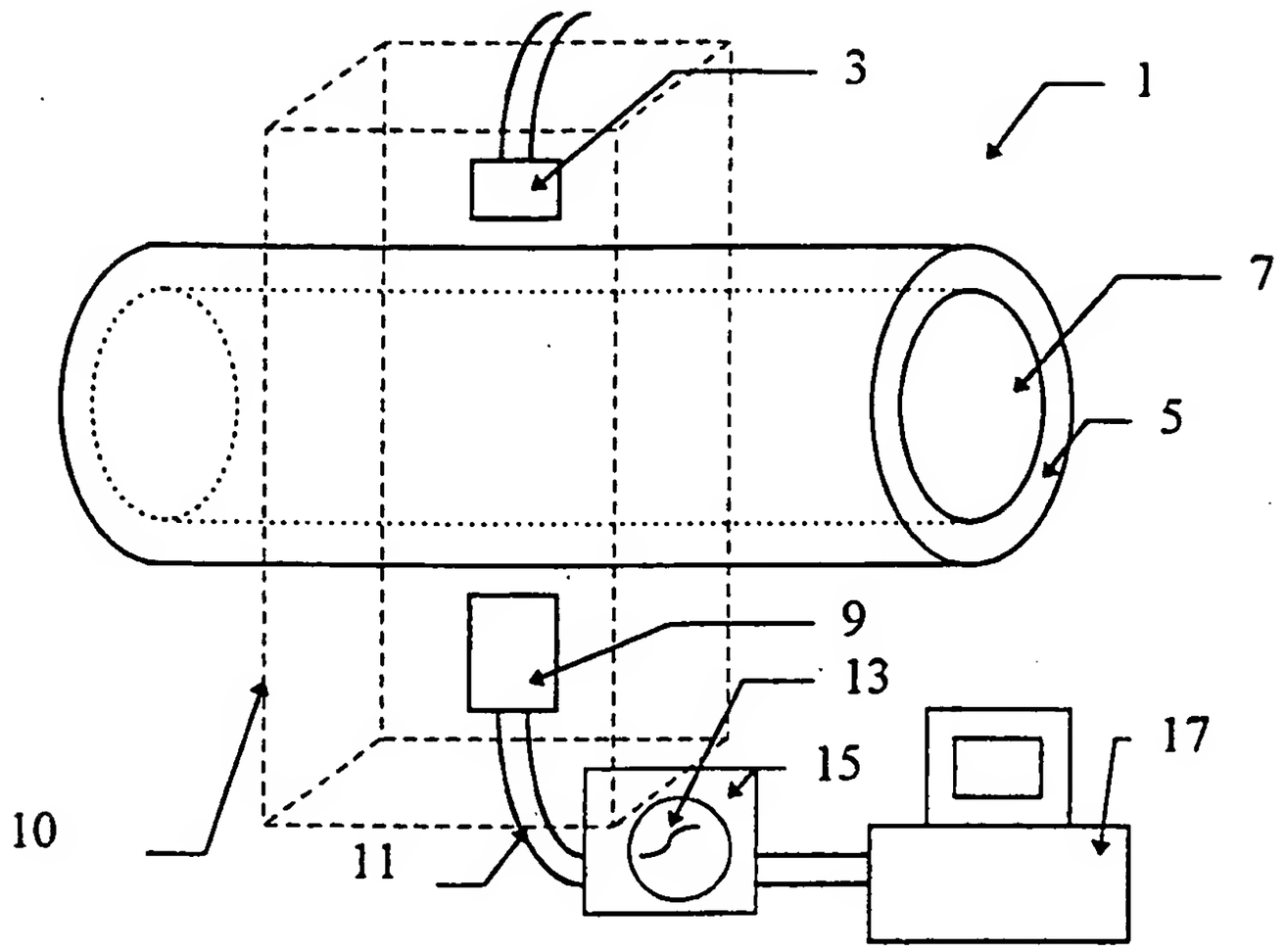
determining the composition of said fluid by comparing the amount of the beam passing through said fluid against the amount of said beam passing through samples of known composition.

10. Method according to claim 9 characterised in that said comparing is performed by a computer (17).

11. Method according to claim 9, characterised by, in order to determine the composition of said fluid, studying a signal from said detecting means (9) having different characteristics depending on whether a clear mixture of air and/or water is present or an opaque mixture of milk and water, or only milk.

12. Method according to claim 11, characterised by placing a suitable colour detecting means, such as a removable colour filter in the beam path, when coloured contamination is to be detected.

Fig. 1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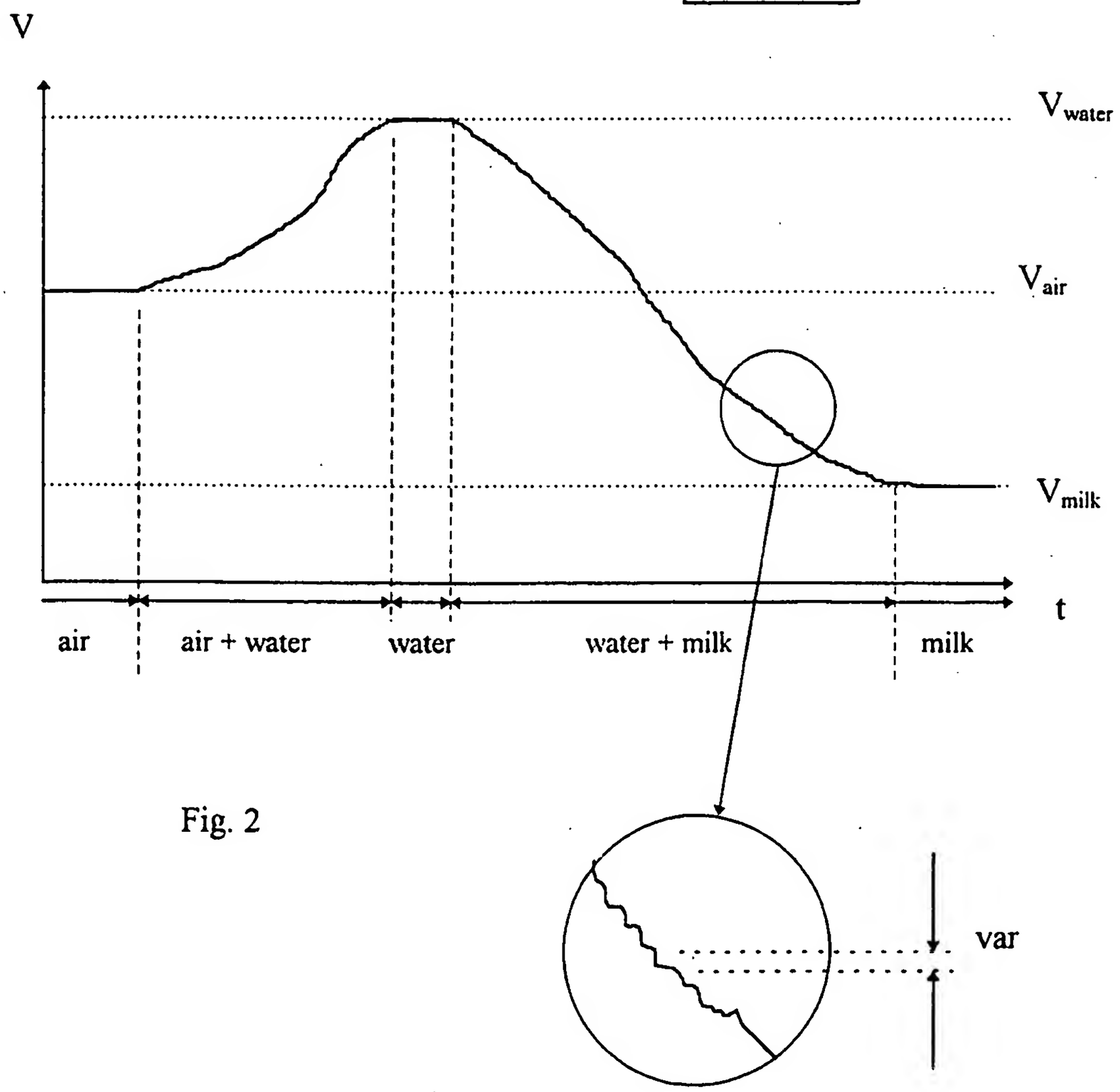
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Fig. 2

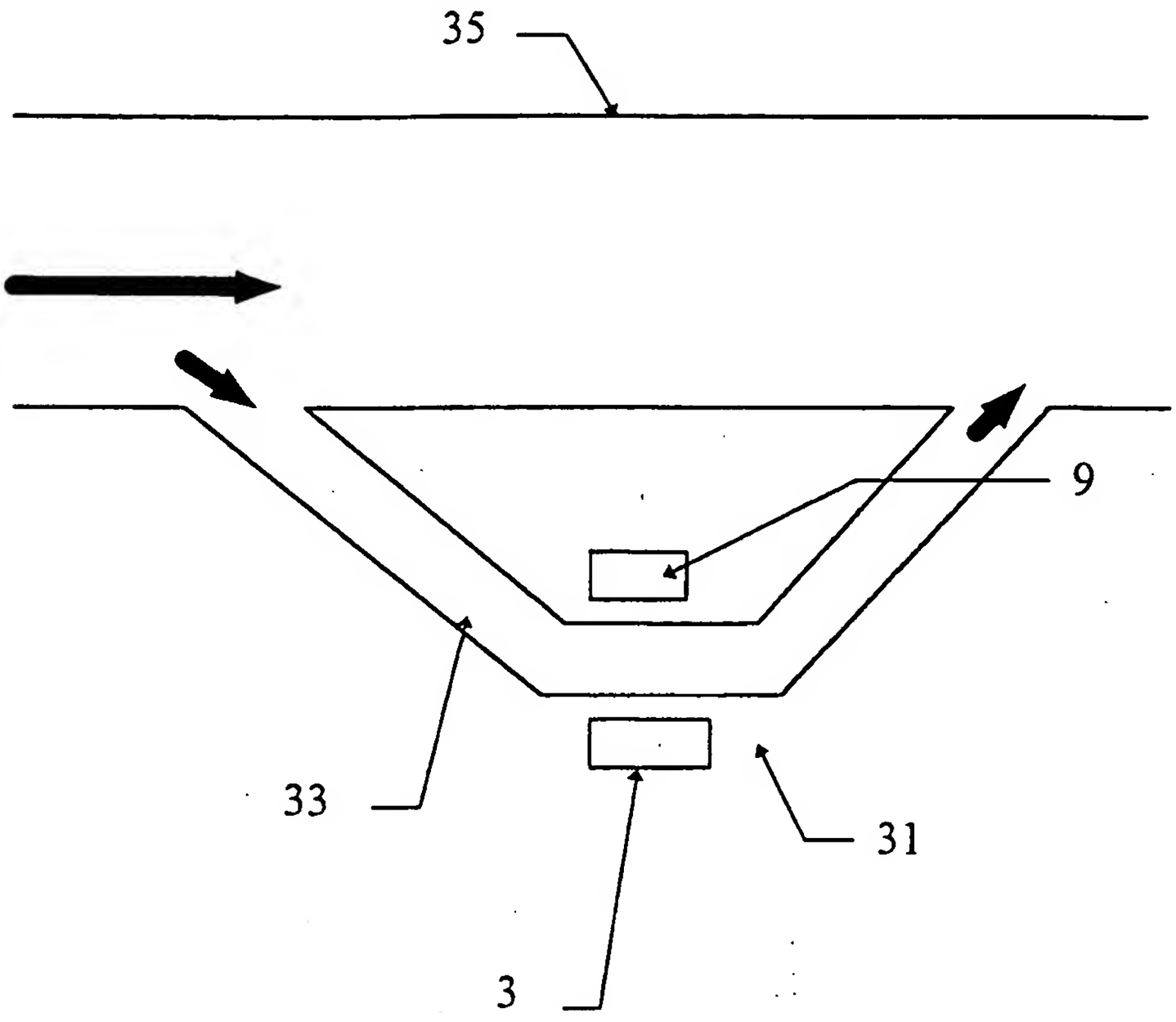

Figure 3

INTERNATIONAL SEARCH REPORT

Inte.national application No.
PCT/SE 99/01451

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G01N 33/04, G01N 21/85
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9624835 A1 (WOLFKING DANMARK A/S), 15 August 1996 (15.08.96), page 4, line 33 - page 5, line 7; page 5, lines 21-22; page 6, line 21 - page 7, line 8 -- --------	1-12

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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